Principal Modes of High-Resolution Spectral Variability in Tropical Cloud Systems

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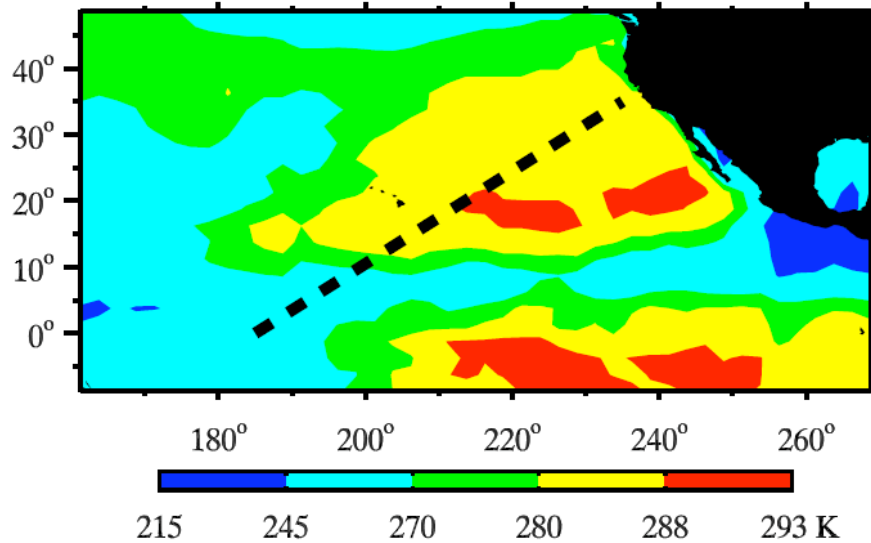
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Pacific Cross Section

1-30 July, 2005
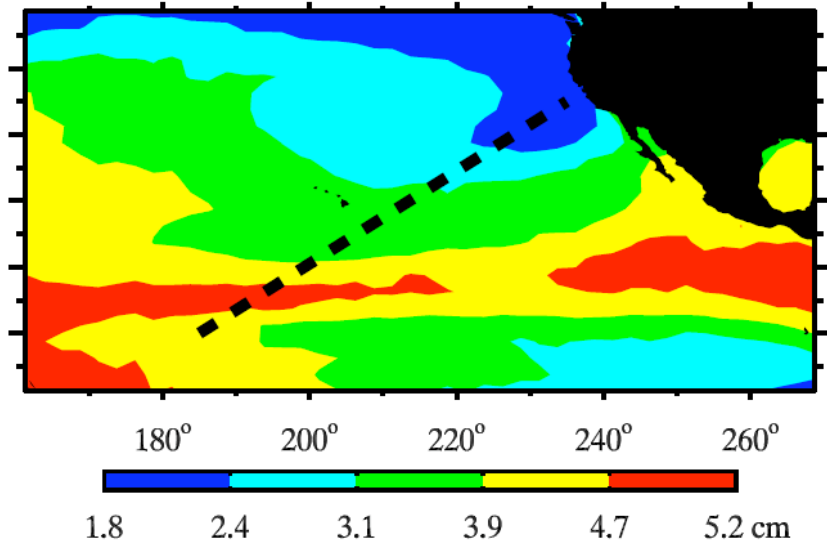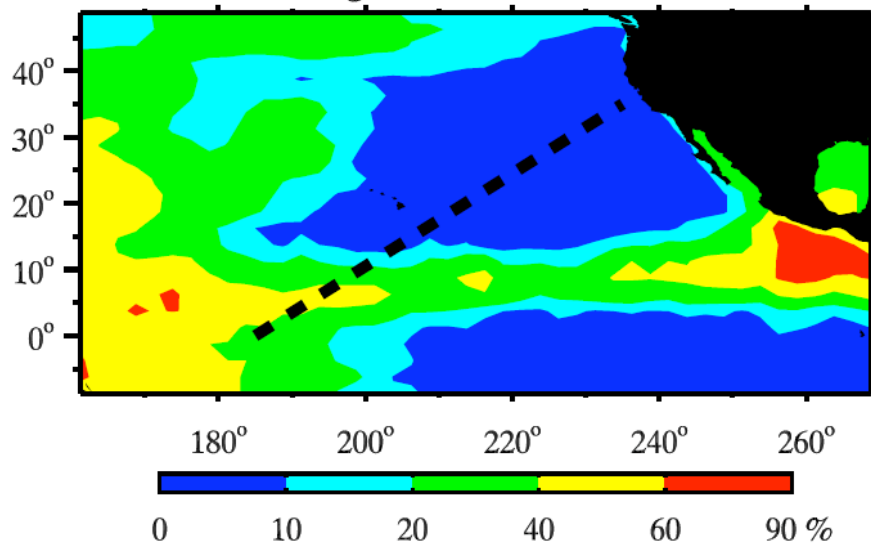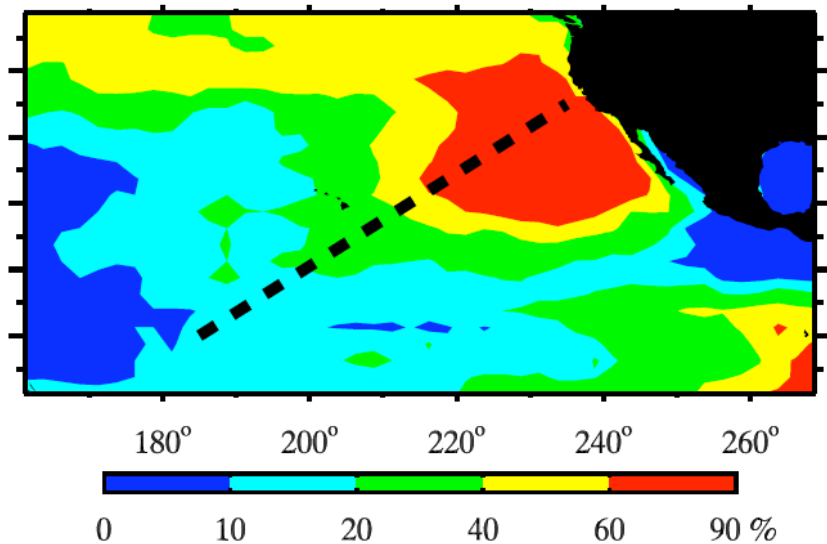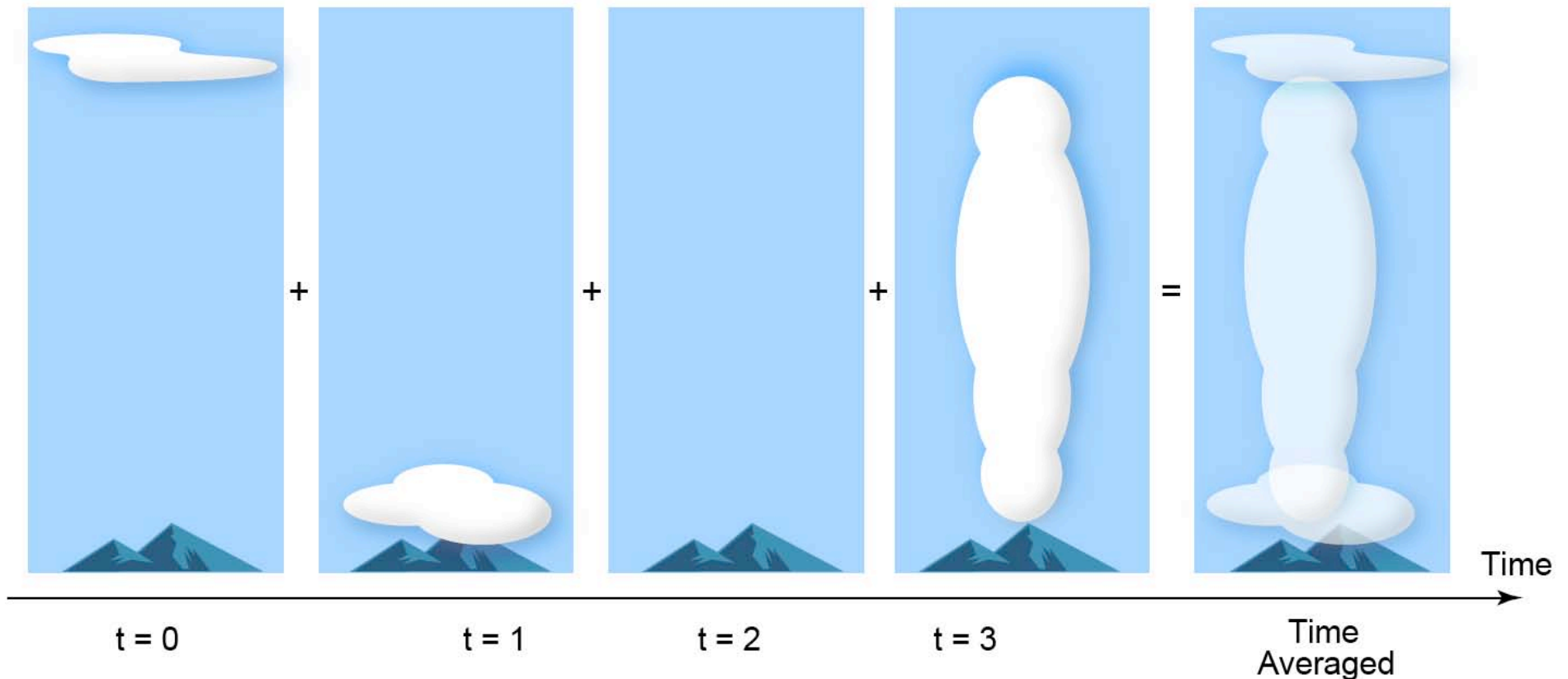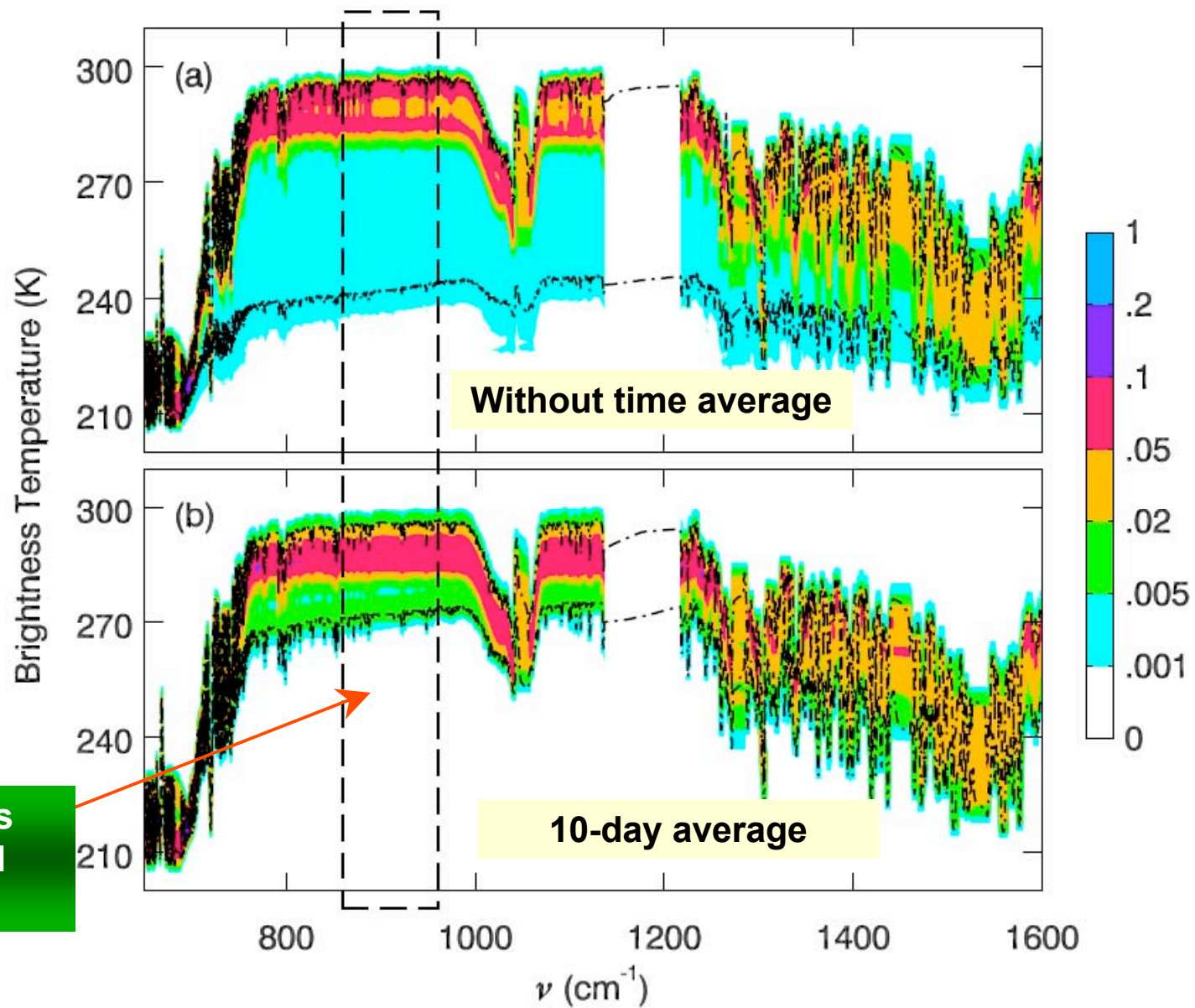
Cloud mixing upon time averaging

➢ Cloud processes are non-linear
➢ Sequence of time and spatial averaging is important

t = 0 + t = 1 + t = 2 + t = 3 = Time Averaged

Time

Without time average

10-day average

High clouds got washed out!

Probability distribution functions (pdfs) of the AIRS channels from 2005 July data over the Pacific cross section.

• — • — 95 percentile boundary

Instantaneous Principal Component Analysis (I-PCA)

➢ Methodology:

❑ Given a set of spectra $I(\mathbf{x}, t, \nu)$
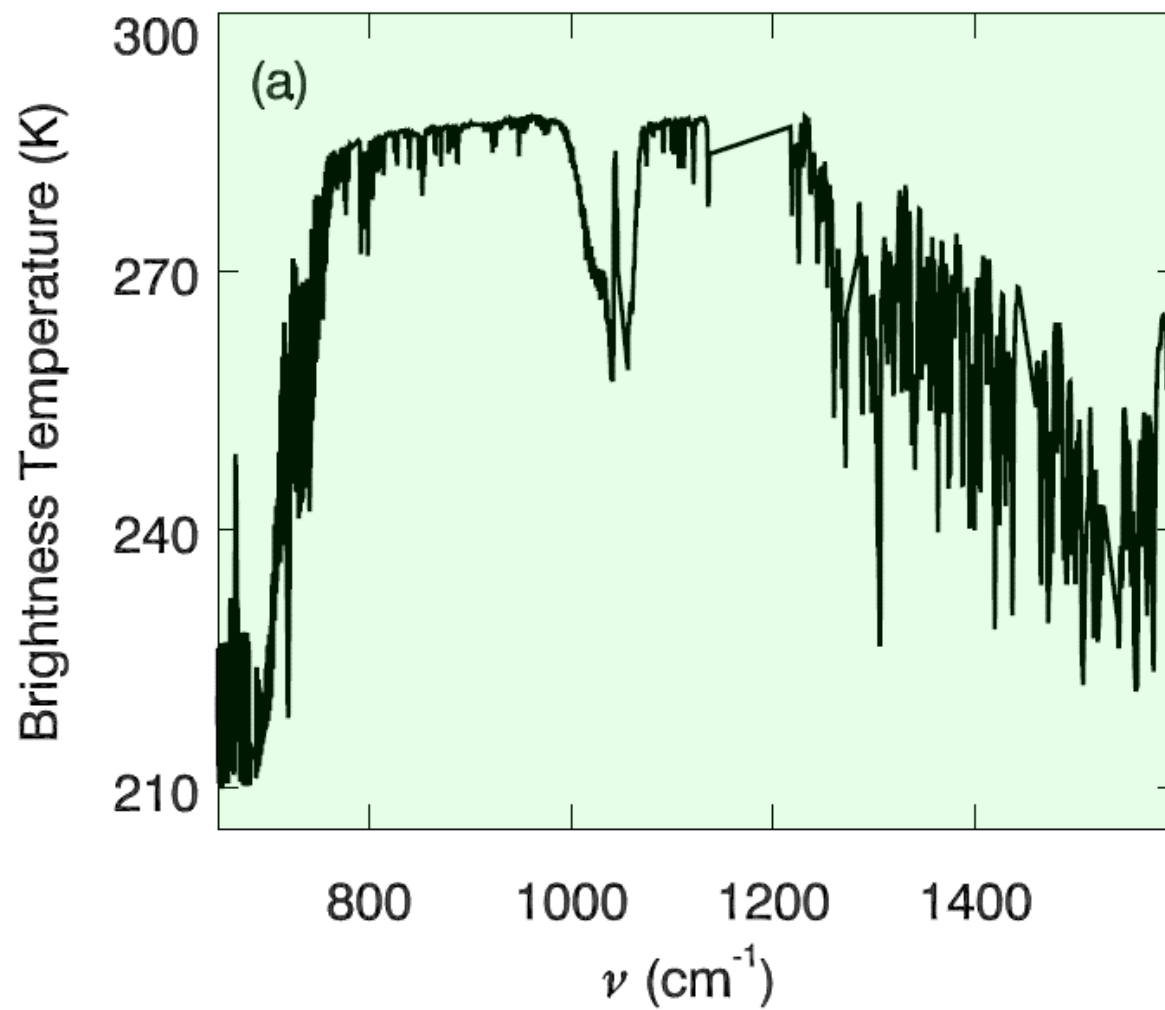
❑ Empirical orthogonal functions expansion

$$I(\mathbf{x}, t, \nu) = \overline{\langle I(\nu) \rangle} + \sum_m f_m(\mathbf{x}, t) g_m(\nu)$$

$$\sum_{\mathbf{x}, t} I(\mathbf{x}, t, \nu) \big/ N_{\mathbf{x}, t}$$ **Expansion coeff.** **EOFs**

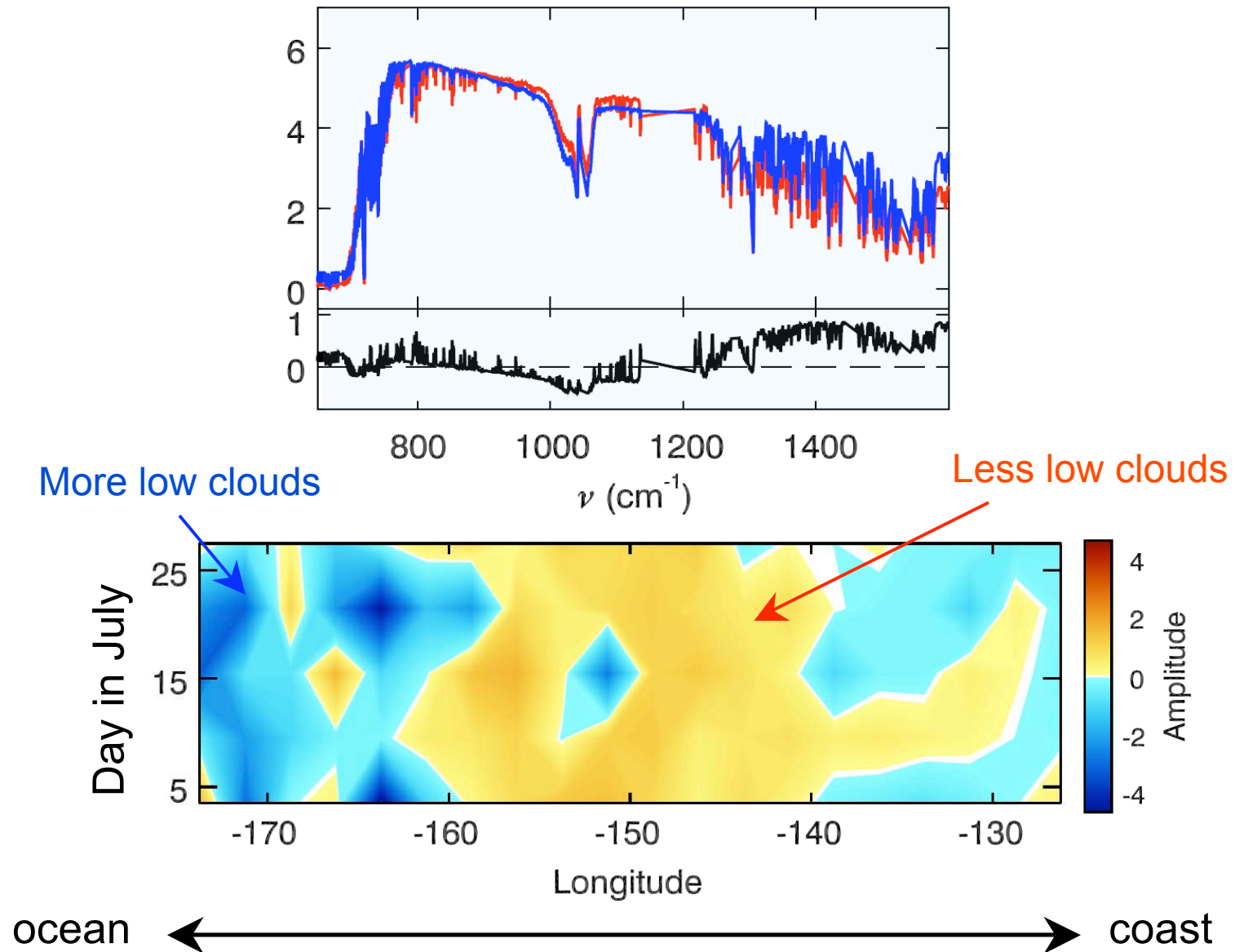❑ Do time averaging over the expansion coefficients

$$\langle I(\mathbf{x}, \nu) \rangle = \overline{\langle I(\nu) \rangle} + \sum_m \langle f_m(\mathbf{x}) \rangle g_m(\nu)$$
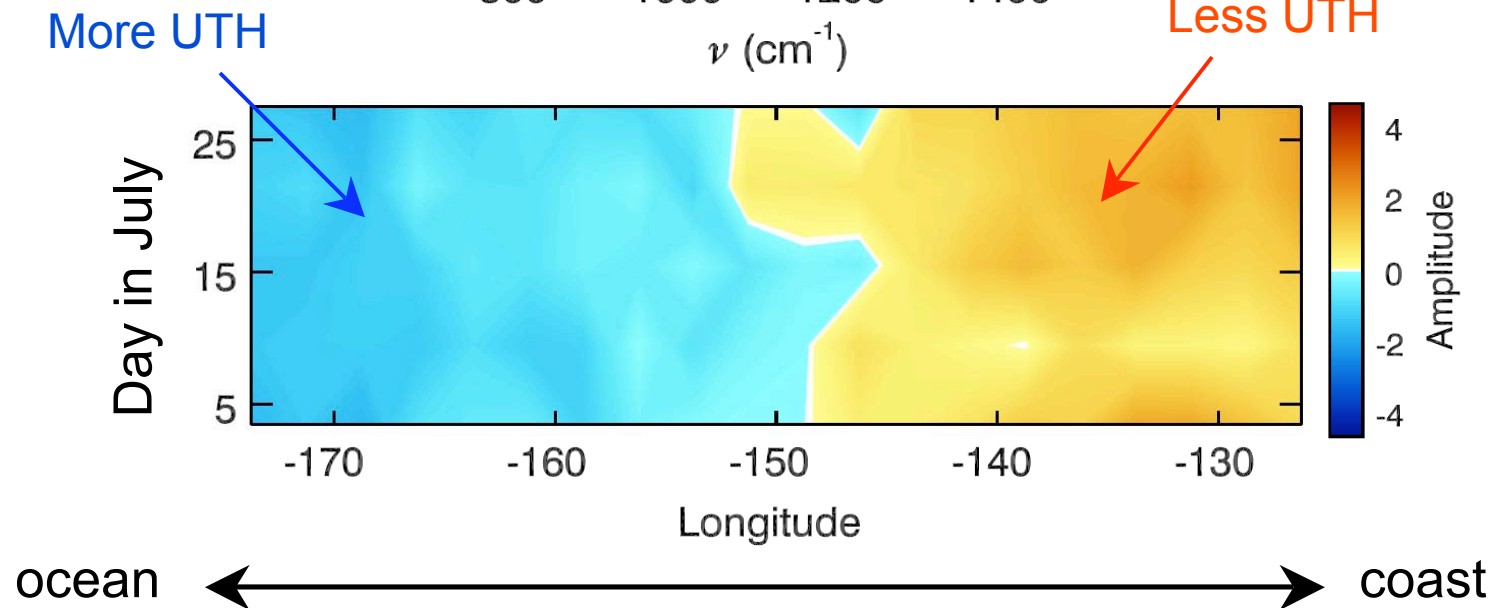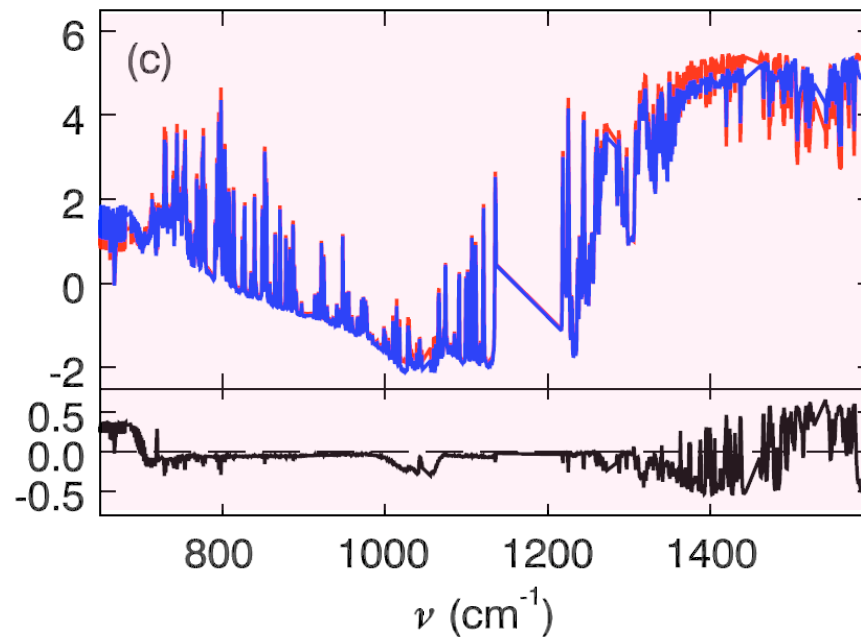
Spectral Mean

1st Principal Mode

2nd Principal Mode

❖ Implication:

  ❖ Future missions on cloud studies must be careful of defining the spatial resolution of the measurement

❖ Limitation:

  ❖ AIRS footprint ~ 13.5 km

    → clouds are already mixed

    → Cross-data set comparison (e.g. with MODIS ~ 1 km)

Summary

- AIRS spectra have been employed to study a tropical cloud system
- Time-averaging might lead to unrealistic cloud scenes and mix underlying basic states (e.g. high/low clouds)
- I-PCA preserves all information in both space and time
  - Maximizes separation of the basic states
  - Allows the study of the time evolution of the physical system
- GCM simulations must also reproduce the covariances of these phenomena